# Tackling antimicrobial resistance: Adsorption of meropenem and ciprofloxacin on lignocellulosic substrate from sawdust

Ulster University

Faculty of Life & Health Sciences

# Tackling Antimicrobial Resistance: Adsorption of meropenem and ciprofloxacin on lignocellulosic substrate from sawdust

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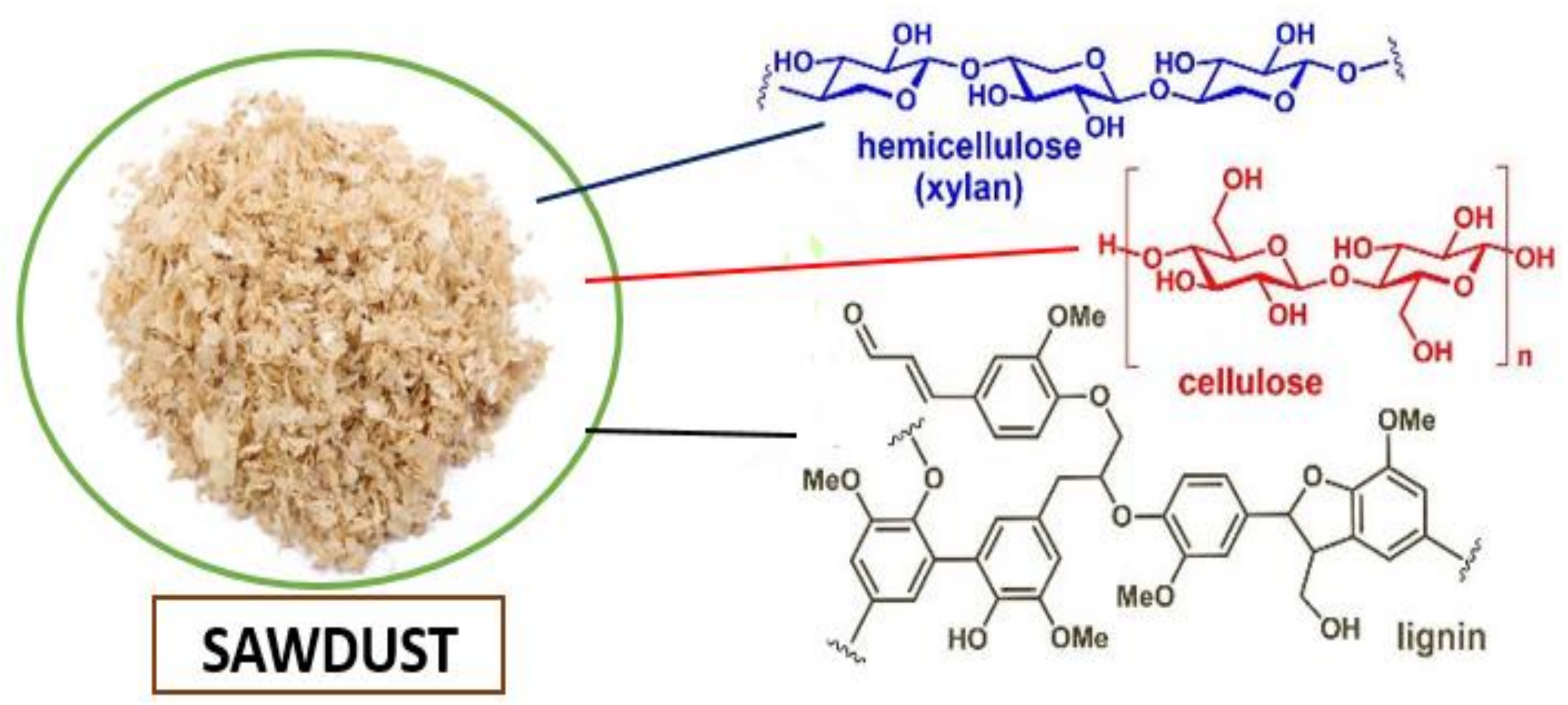
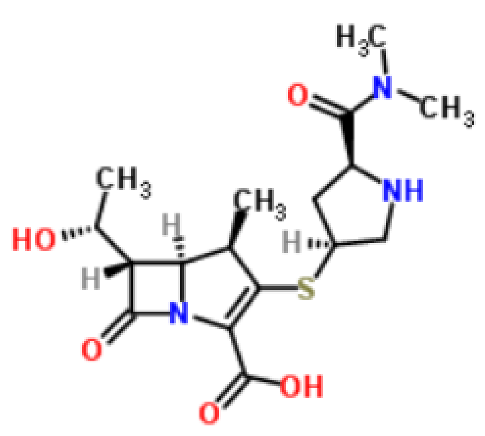
## Introduction

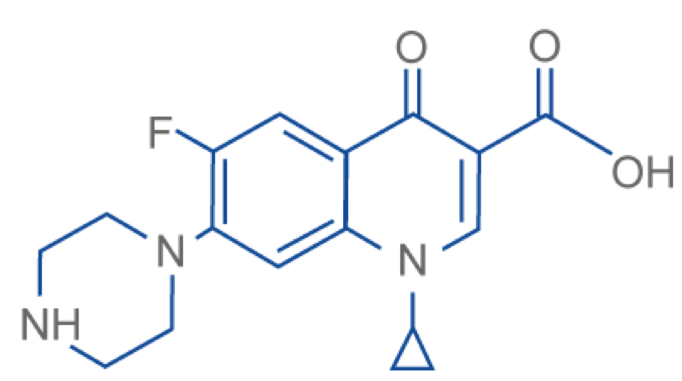
Antimicrobial resistance (AMR) is the phenomenon in which microorganisms survive a therapeutic dose of antimicrobials through the possession or acquisition of resistant traits. The release of antibiotics into aquatic environments through wastewater effluents is suspected to contribute to proliferation and amplification of AMR with adverse effects on human and animal health. Conventional secondary and tertiary treatment technologies are partly effective in removing antibiotics from contaminated water. Polishing of effluent through adsorption onto activated carbon is effective but costly. This project investigates the efficacy of sawdust for such an adsorption treatment. As a lignocellulosic waste product, its application has a potential economic advantage (1). The choice of meropenem and ciprofloxacin for this study is because both antibiotics are listed by World Health Organization (WHO) as important antibiotics at risk of losing therapeutic efficacy due to the spread of resistance among priority pathogens (2).




CHEMICAL COMPOSITION OF SAWDUST



MEROPENEM



CIPROFLOXACIN

## Aim and Objectives

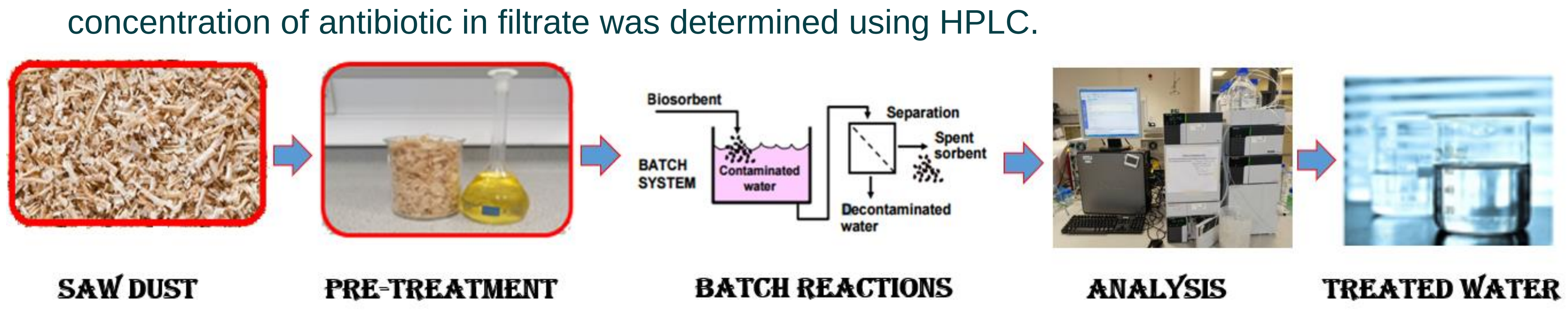
The aim of this study is to investigate the potential of this treatment method for removing antibiotics from water, using sawdust as a bio-adsorbent.

The objectives of the current study include:

1. Design antibiotic removal systems using sawdust.
2. Determination of meropenem and ciprofloxacin antibiotics in water.
3. Modification of sawdust with the view to improve accessibility of its functional groups.
4. Investigation of the effect of adsorption factors, such as contact time and pH, on the removal of meropenem and ciprofloxacin.

## Methods

- Concentrations of meropenem and ciprofloxacin antibiotics in aqueous solution were detected using Shimadzu HLPC instrument (CBM-20A model) fitted with a prominence diode array (PDA) detector and a C-18 reserve phase, 250 × 4.60 mm 5 micron column.
- Calibration curve (CC) for ciprofloxacin was developed for the concentration range of 0.25 – 10 µg/mL at wavelength 278 nm, while that of meropenem was determined from the concentration range of 1.56 - 10 µg/mL at 290 nm.
- Sawdust was sourced from Sitka spruce tree and collected from local saw mill in Coleraine. It was washed, dried and sized (250 um) to produce untreated, raw sawdust (RSD). Treated sawdust (TSD) was obtained following a treatment of RSD with 2 M sulphuric acid.
- Adsorption experiments were conducted with mostly 1 g portion of the sawdust (adsorbent) in contact with 25 mL of 10 µg/mL for meropenem and 7 µg/mL for ciprofloxacin antibiotic (adsorbate) for 24 hours in a Medline SI-600R incubator shaker at 150 rpm, 25 $^{o}$C and pH 6-7. The suspension was separated after 24 hrs by filtration under vacuum, while the equilibrium concentration of antibiotic in filtrate was determined using HPLC.




GRAPHICAL ILLUSTRATION OF THE METHODS

## Results and Discussion

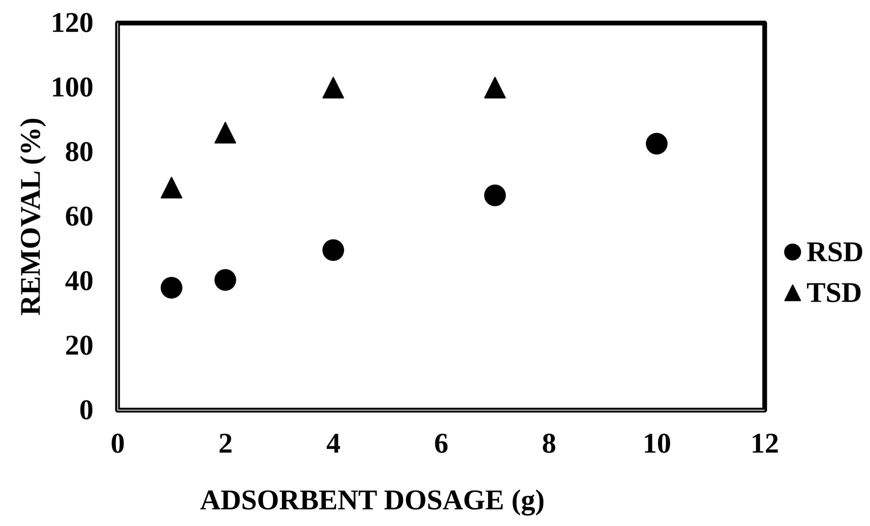



**Figure 1: Effect of adsorbent dosage on the removal of meropenem.**

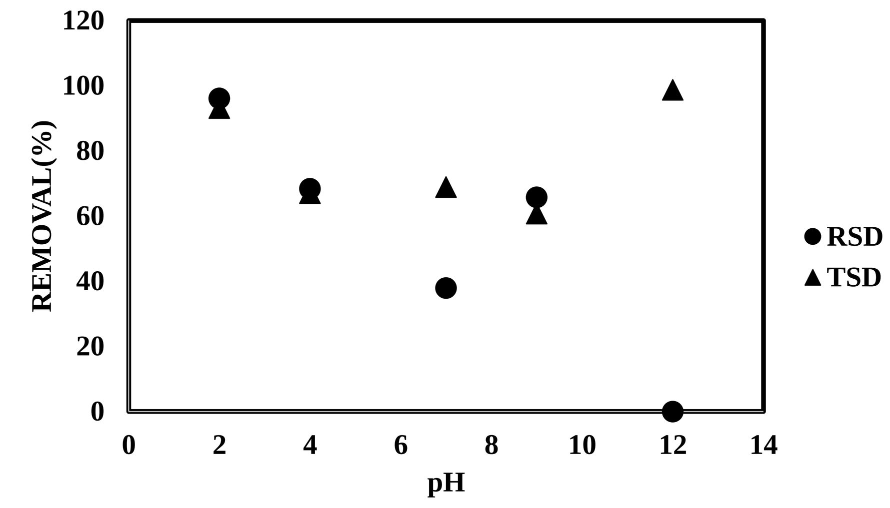



**Figure 2: Effect of pH on the removal of meropenem.**

Both RSD and TSD removed meropenem from water. For TSD, however, the removal of meropenem was significantly enhanced presumably due to the fact that chemical treatment increases the accessibility of functional groups in the sawdust. The effect of adsorbent dosage was investigated; **Figure 1** showed that the removal of MER increased as the amount of the untreated sawdust increases for both RSD and TSD. This is because the amount of adsorbent determines the number of active sites available on its surface for adsorption. Furthermore, the removal efficiency of TSD was higher than RSD by at least 30%, as the amount of adsorbent increases and 4g of TSD removed meropenem below the limit of detection.

The results illustrated in **Figure 2** showed the variability of the removal of meropenem at different pH for both RSD and TSD. For RSD, the removal of meropenem was favourable in acidic condition than in alkaline condition with the highest percentage removal at pH 2 which could be attributed to the following adsorption mechanisms: possible hydrogen bonding interactions between the functional groups of both the sawdust and the drug, and electrostatic interactions between the particles of the sawdust and the drug. Similarly, the most efficient removal of meropenem using TSD was experienced in low pH values except for pH 12.

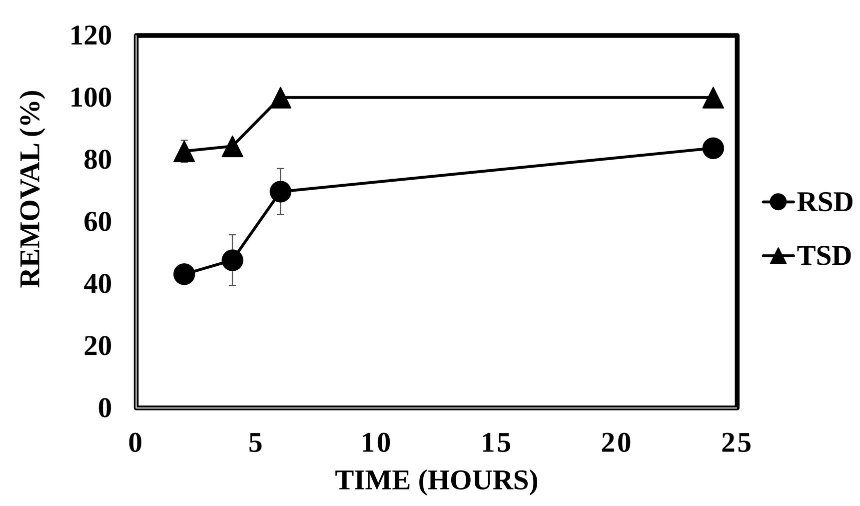



**Figure 3: Effect of contact time on the removal of ciprofloxacin.**

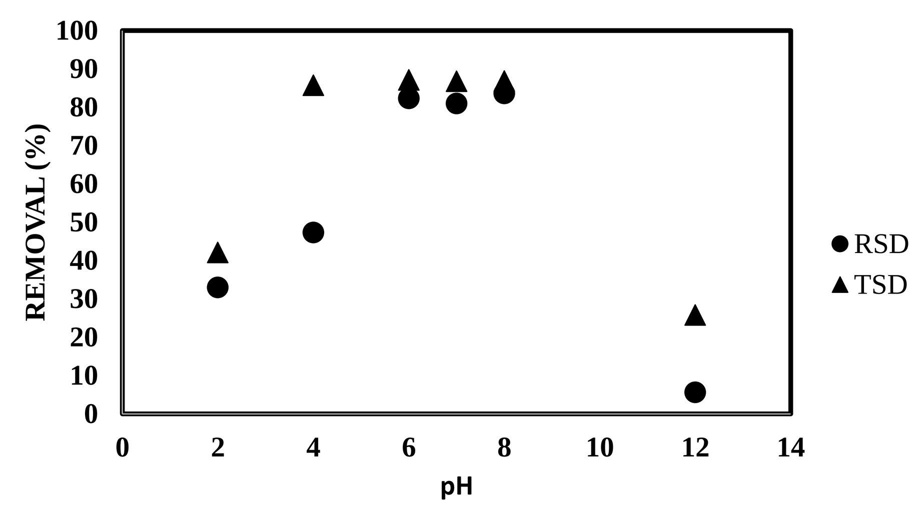



**Figure 4: Effect of pH on the removal of ciprofloxacin.**

RSD and TSD reduced the concentration of ciprofloxacin antibiotic in aqueous solution (**Figure 3**). However, TSD was more effective because acid treatment improved its adsorption capacity. The rate of removal of ciprofloxacin was evaluated, with 24 hours being the optimum time for RSD and 6 hours for TSD. Diffusion resistance and repulsive force might be responsible for slowing down the adsorption.

The role of pH on ciprofloxacin removal was investigated for both RSD and TSD adsorbents (**Figure 4**). Higher uptake of ciprofloxacin was observed at pH 6, 7 and 8 for RSD adsorbent, while optimum removal of the drug was detected in pH 4, 6,7 and 8 for TSD. This uptake might be due to the strong electrostatic force between the surface of the sawdust and ciprofloxacin. Conversely, the lowest removal for both RSD and TSD was at pH 12 which may be principally attributed to electrostatic repulsion between particles of the sawdust and ciprofloxacin.

## Conclusions

- Raw sawdust and sulphuric acid-treated sawdust reduced the concentration of meropenem and ciprofloxacin antibiotics in aqueous solution by over 70%, thereby indicating that this technology is a promising method for treating antibiotics in contaminated water.
- The degree of removal increased as the mass of the adsorbent increases.
- The pH of the solution plays an important role in the removal of meropenem and ciprofloxacin. While meropenem is best removed at low pH value (pH 2), ciprofloxacin removal favours intermediate pH values (pH 6 - 8).

## References

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2. WHO (2017). *List of bacteria for which new antibiotics are urgently needed*. Available at: http://www.who.int/mediacentre/news/releases/2017/bacteria-antibiotics-needed/en/